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Efficiency of the Strategies to Prevent and Mitigate the Deforestation in Costa Rica

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1. Introduction

During the 2000-2010 period, worldwide deforestation, mainly due to conversion of forests to agricultural lands, was responsible for the loss of 5.2 million ha of forest per year or 140 km² of forest per day (Food and Agriculture Organization of the United Nations [FAO], 2010a). During this same period, Central America loss 248,000 ha of forest per year and, with the exception of Costa Rica, the forest cover continues decreasing in the area (Food and Agriculture Organization of the United Nations [FAO], 2010a). Tropical forest deforestation and the consequent habitat loss and forest fragmentation are among the main causes of the global decline in biodiversity (Brook *et al.*, 2003; Sehgal, 2010). For this reason, studies evaluating the efficiency of the strategies contributing to prevent, minimize, and revert the forest covert loss are critical for the long-term survival of many species of plants and animals (including human beings).

Costa Rica is often hailed as a model for how developing nations can balance the protection of the nature and the economic development. The country is recognized to devoted *ca*. 25% of its territory to forest conservation and for the income that the country generates from different sustainable activities (Buchsbaum, 2004; Food and Agriculture Organization of the United Nations [FAO], 2010a).

However, the "conservationist" reputation of the country is relatively recent and largely contrasts from the unsustainable practices driving the economic model of Central America during the second half the XX century. Overall, the land speculation by cattle ranchers in combination with interest rate subsidies (i.e., financial incentives widely provided by government entities and public banks) is pointed as the main cause of deforestation in Costa Rica and in the rest of Latin America (Kull *et al.*, 2007; Roebeling & Hendrix, 2010). Thus, since 1960 most government policies, national and international investment, and international cooperation programs have all promoted the deforestation, colonization, and "hamburgerization" (i.e., the pasture expansion for the beef industry proliferation for export to USA) of the Central American land (Harrison, 1989; Myers, 1981). As result of these "depredatory" politics, Costa Rican's forest cover decreased from 2.71 million ha in 1950 to 1.01 million ha in 1983, while the deforestation rates increased from 36,018 ha/year during the 1950-1961 period to 97,317 ha/year during 1977-1983 (reviewed by Harrison, 1989). However, the economic balance for the beef industry was extraordinary positive because the number of head cattle exported to USA explosively increased from 6903 in 1955 to 148,882 in 1973. Even after 1983, the Costa Rican's government across the Instituto de Desarrollo

Agrario (IDA) continued promoting the deforestation and clearing of 500,000 ha of "underutilized lands" (i.e., forested or partially forested lands). Most of these lands were distributed among poor "campesinos"and/or small farmers to incentive the agriculture (Harrison, 1989).

Although there is a complex network of environmental, social, economic, and politic factors influencing the changes in forest cover in the country (Calvo-Alvarado *et al.*, 2009; Kull *et al.*, 2007; Sánchez-Azofeifa *et al.*, 2001; Sánchez-Azofeifa & Van Laake, 2004), most studies highlight the importance of the ecotourism, the payments for environmental services, the private nature reserves, and the environmental education as strategies to prevent, minimize, and/or revert the deforestation in the country. These four factors are described below.

1.1 Ecotourism

Ecotourism is often perceived as an excellent tool for sustainable development in developing countries (Almeyda *et al.*, 2010; Gossling, 1999). Among the main benefits of this "green" economic strategy frequently are mentioned: (1) the protection of forest resources and hence the prevention of deforestation in general, and (2) the economic benefits for local communities (Gossling, 1999; Horton, 2009).

Since the boom of the ecotourism in Costa Rica, at the end of 1980s and into the 1990s, the activities related with ecotourism (e.g., proliferation of eco-lodges and/or private reserves, nature-tours, and agro-ecotourism), represent one of the main economic activities of the country (Koens *et al.*, 2009; Weaver, 1999). Corresponding with this "boom", the hotel sector in the country has grown over 400% from 1987 to 2000 (Instituto Centroamericano de Administración de Negocios [INCAE], 2000). As result, the agro-export economic model based in the extensive plantations of coffee and banana (i.e., the main economic activity since the nineteenth century), was displaced to a secondary place as source of economic resources (Iveniuk, 2006). Thus, annually *ca.* 1.2 million tourists visit the country, which result in an annual turnover range from US$ 1200 million in 2003 to US$ 1983 million in 2010 (Instituto Costarricense de Turismo [ICT], 2011a).

Although the above, some researchers question the contribution of the ecotourism to conservation and community development due to some potential negative impacts such as habitat destruction, waste generation, visitor impacts, and socio-cultural ills (Stem *et al.*, 2003; Wearing & Neil, 2009). Below I discuss this topic in the light of the evidence provided by different case studies in Costa Rica.

1.2 Payments for Environmental Services (PES)

The payment for environmental services is an economic incentive received to the landowners for the services and goods provided for their forested lands or forest patches (Sánchez-Azofeifa *et al.*, 2007). In Costa Rica the current PES system was created with the 1996 Forestry Law 7575, which recognizes four main environmental services: mitigation of green house gas emissions, hydrological services, biodiversity conservation, and provision of scenic beauty for recreation and ecotourism (Kull *et al.*, 2007; Sánchez-Azofeifa *et al.*, 2007).

The Forestry Law 7575 provides the legal and regulatory basis to contract with landowners for the environmental services provided by their lands, empowers the National Forestry Financing Fund (FONAFIFO) to issue such contracts, and establishes a financing mechanism for this purpose (Sánchez-Azofeifa *et al.*, 2007; Sierra & Russman, 2006). Previously to receive the PES economic benefits, the landowners need sign a 5-10 year contract with the

government, agreeing to either protect forest cover or engage in reforestation. Funding for PES program comes from a 3.5% fossil fuel tax, private-sector and international donor contributions, a World Bank loan, and the sale of carbon offsets to industrialized countries established in the Kyoto Protocol (Kull *et al.*, 2007).

The percent of the country territory receiving PES increase from 5.5% (representing 4400 contracts) in 2001 to 7.3% (representing 4600 contracts) in 2010 (National Forestry Financing Fund [FONAFIFO], 2011). According with the same source, currently PES covers 373,074 ha of forests in different succession stages and protects *ca.* 2.7 million of trees throughout the 7 provinces of the country. Although this program might facilitate field abandonment in some marginal zones already affected by agricultural liberalization (Sierra & Russman, 2006), its relative efficiency as deforestation-avoiding strategy is even polemic.

1.3 Private nature reserves

Traditionally, conservation efforts to preserve the Costa Rican' natural legacy (i.e., ecosystems and species) have been focused on the establishment of government-controlled areas such as national parks, wildlife refuges, biological reserves, and other management categories (Food and Agriculture Organization of the United Nations [FAO], 2010b). However, with the boom of the ecotourism at the end of 1980s and into the 1990s (see above), this fact has changed noticeably. Thus, the number of private reserves registered increases from 65 reserves in 2005 to *ca.* 200 reserves in 2011 (Red Costarricense de Reservas Naturales, 2011).

Overall, private reserves range from 20 to 1500 ha in size (Herzog & Vaughan, 1998; Red Costarricense de Reservas Naturales, *pers. comm.*) and together cover over 81,429 ha of forests along the country (Red Costarricense de Reservas Naturales, 2011). This fact highlights the importance of private landholdings in the fate of the Costa Rican forests, particularly in the trends in the forest cover along the time.

1.4 Environmental Education (EE)

Environmental education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among men, his culture and his biophysical surroundings (International Union for the Conservation of Nature [IUCN], 1970). Overall, acording to Jacobson (1991) a well-designed and well-implemented EE program have the potential to increase ecological awareness, foster favorable attitudes toward the environment, and promote the conservation of the natural resources (including discourage of deforestation and/or selective logging). Even, some authors consider that an appropriate EE might produce significant behavioral changes in the people and hence, may be more crucial to successful long-term conservation than a strictly scientific work (Blum, 2008; Jacobson, 1991; Palmer, 1998).

In this sense, since 1980s Costa Rica has been one of the world-leaders in efforts to promote environmental learning and national policies integrating education, conservation, and different sustainable activities related to ecotourism (Blum, 2008). For instance, as early as 1975, the Universidad Nacional (one of the most important public universities in the country) established a School of Environmental Sciences which included an environmental education program. Similarly in 1994, the National Council of Vice-Chancellors created an Inter-University Commission for Environmental Education which works to 'environmentalise' all of the state universities (Oficina de Educación Ambiental, 2002). Currently, most of the

environmental education in Costa Rican schools and/or communities is supported by the Ministry of Environment and diverse non-governmental organizations (Blum, 2008).
Nevertheless, to date the controversy on the relative efficiency of the aforementioned factors as deforestation-avoiding strategies still persist. Some authors concludes that the current expansive network of efforts in conservation, environmental management, education and ecotourism contribute directly to prevent and minimize the deforestation in the country (e.g., Blum, 2008). Conversely, other authors support that the forest cover recovery in some areas of Costa Rica have been result of a process referred as "forest transition" (i.e., deforestation trends are replaced with reforestation following the trends in the economic development and urbanization), rather a direct effect of the environmental policies (Calvo-Alvarado *et al.*, 2009; Schelhas & Sánchez-Azofeifa, 2006). Therefore, in this chapter I reviewed the available literature to assess the relative efficiency of the ecotourism, PES, private reserves and environmental education to prevent, mitigate, and/or reverts the deforestation in different regions of Costa Rica. Finally, I synthesize the major strengths and weaknesses of these strategies and suggest future directions to minimize the deforestation and to improve the environmental performance in the country.

2. Methods

2.1 Literature review

To achieve the main objectives of this study, I conducted a systematic review of published articles, book chapters and dissertations up to August 2011 using ISI Web of Science, Biological Abstracts, Google Scholar, and Costa Rican environmental agencies online data bases. Overall, I amassed a total of 90 studies on the study topic distributed as follow: 36 studies on ecotourism, 17 studies on payment for environmental services, 8 studies on private nature reserves, and 29 studies on environmental education.

2.2 Efficiency indicators

To determine the efficiency of the above mentioned strategies I used changes in deforestation rates and/or forest cover before the implementation of each strategy and 4-20 years after its implementation in the same region. As sources of the information on the deforestation rates and/or forest cover in the sites in which a particular strategy was implemented, I used the information available in the literature and in online data bases from the Ministerio del Ambiente, Energía y Tecnología (MINAET) de Costa Rica (http://www.minae.go.cr/), Sistema de Infomación de Recursos Forestales (http://www.sirefor.go.cr), Fondo Nacional de Financiamiento Forestal (http://www.fonafifo.com/), Oficina Naciona Forestal (ONF), Tribunal Ambiental Administrativo (http://www.tribunalambiental.org), and Centro de Derecho Ambiental y de Recursos Naturales (http://www.cedarena.org/).

2.3 Statistical analysis

To evaluate if forest area covers by private and public forests differed between years, I used generalized linear models (GLM: Lehman *et al.*, 2005). I constructed the following model: AREA = FOREST TYPE (PRIVATE AND PUBLIC) nested within YEAR + FOREST TYPE*YEAR. Data were first arcsine transformed, and tested for a normal distribution with a Shapiro-Wilk test (passed, $P>0.05$). I then selected Normal distribution with an identity link-function to the response variable. I performed the statistical analyses using JMP (version 7.0, SAS Institute, Cary, NC).

Case study	*Location (coordenates)*	*Positive aspects*	*Negative aspects*	*Ref.*
Monte Verde Could Forest Reserve	Puntarenas province (10°18'25.14"N, 84°48'35.03"W)	1) Protection over 10,500 ha of could forest, including different threatened species of animals and plants. 2) Protection of an important water reservoir for the region. 3) Promotion of environmental education and sustainable management of resources across the non-profit organization Monte Verde Institute 4) Generation of feeds for local inhabitants inside and outside the reserve. 5) Creation of a women s handicraft cooperative with nearly 100 members.	1) Trail and soil erosion with the increase in the number of visitors. 2) Potential pollution and/or over-exploitation of the water reservoir	Buckley (2003)
Rara Avis Reserve	Heredia province (10°16'52.23"N, 84° 2'43.09"W)	1) The reserve directly conserves 485 ha of primary rainforest and has indirectly conserved an additional 1000 ha. 2) Protection of more than 500 species of trees and palms, and over 362 species of birds. 3) By protecting the forest, the reserve has avoided the emission of over 337,000 of CO2, which would have been emitted had the forest been cut, as was planned by the previous owners. 4) Promotion of environmental education and alternative sustainable uses of the rainforest. 5) Low-moderate number of visitors along the year, which minimizes the human disturbance in the area. 6) Promotion of the scientific research on the birds, amphibians and trees.	1) No clear economic benefits for the neighbor communities.	Buckley (2003)
Punta Islita Eco-lodge	Nicoya, Guanacaste province (9°51'23.80"N, 85°23'55.89"W)	1) The eco-lodge property increased in forest cover from 4% to 76% from 1975 to 2008. 2) Protection of 27 ha of tropical dry forest. 3) Provide employment for 175 local inhabitants and indirect employment for an undetermined number of permanent residents. 4) By generation employment for local inhabitants, has contributed to reduce the problems such as alcoholism, drug addiction, and prostitution.	1) Future increase in deforestation rates due to uncontrolled development of hotels and housing projects.	Almeyda *et al.* (2010)

Table 1. Three study case on ecotourism efficiency in different top tourism areas of Costa Rica.

3. Results and discussion

3.1 Relative efficiency of ecotourism

Overall, the findings for the three analyzed case studies (Table 1) concur with previous studies suggesting that ecotourism represent a valuable tool for conservation and sustainable development (e.g., Almeyda *et al*., 2010; Ceballos-Lascurain, 1998; Wearing & Neil, 2009). Although in the three case studies there are some negative aspects, the general balance undoubtedly can favors the forest protection and the ecosystem regeneration (Table 1). Similarly, there is evidence indicating that the expansion of the ecotourism plays a relevant role in the reduction of the deforestation in Costa Rica. Thus, considering forests on farmlands and non-farmland areas, the deforestation rates decreased from 47,219 ha/year during the 1950-1961 decade to 15,677 ha during 1973-1984 (reviewed by Harrison, 1989), which correspond to the boom of ecotourism in the country (see above).

However, other studies do not support that ecotourism per se have a relevant role as deforestation-avoiding strategy. For instance, Kruger (2005) in his review of 251 ecotourism case studies found that ecotourism did not create enough revenues to prevent 'consumptive' land use (e.g., forest conversion to agriculture or pasture) among households. Furthermore, the increasing development in the ecotourism "hotspots" of Costa Rica (e.g., Nicoya, Monte Verde, Siquirres, Motezuma, Quepos) might result in a higher deforestation in theses areas. Thus, Almeyda *et al*. (2010) mention that uncontrolled development of standard hotel operations and large condo developments in Nicoya, seeks to capitalise on the region's natural beauty and may reverse land cover trends if they are not accompanied by adequate forest conservation strategies and government monitoring.

3.2 Relative efficiency of the PES

Since the implementation of PES the amount of industrial wood extracted from forests gradually decreased from 248,362 m^3 in 1998 to *ca.* 50,000 m^3 in the years 1999-2006 (Figure 1). Conversely, wood derived from agroforestry increased from 458,538 m^3 in 1998 to a maximum value of 673,426 m^3 in 2001 and two years latter this value drop to 205,401 m^3 and remained relatively constant until 2007 (Figure 1). Furthermore, during this period occurred a noticeable increase in the amount of wood derived from forest plantations (mainly *Smelina arborea* and *Tectona grandis*, National Forestry Financing Fund, *pers. comm.*) (Figure 1). Similarly, during the period 2000-2010 (i.e., 15 year after the implementation of PES), the forest area of Costa Rica increased from 2.37 to 2.60 million hectares (Food and Agriculture Organization of the United Nations [FAO], 2010a). However, the history of the forest cover was quite different during the 1980s when the nation was losing 4% of its forest cover annually—the highest deforestation rate in the western hemisphere at the time (Carriere, 1991). Indeed, between 1970 and 1980 more than 7000 km^2 were cleared, and by 1987 total forest cover had been reduced to only 31% of the land mass or approximately 16,000 km^2 (Carriere, 1991).

Currently there are 4599 PES contracts covering 373,074 ha of lands along the country. Most of the area covered by PES (70%) was devoted to forest protection. Similarly, from the four main PES categories, most contracts were devoted to forest protection (54.2%), following by reforestation (29.8%), protection of wildlife areas (6.4%), and forest management (1.5%) (Table 2). This suggests that PES can promotes the protection of the forest cover in different private nature lands, at least during the contract period (i.e., 5-years). However, there was a large variation in the number of contracts and area covered by PES among provinces (Table 2). Alajuela province presented the larger number of contracts (1045 contracts) and

cumulative number of hectares covered by PES (73,516 ha), while the lower values were found in Cartago province (130 contracts and 28,822 ha, respectively) (Table 2).

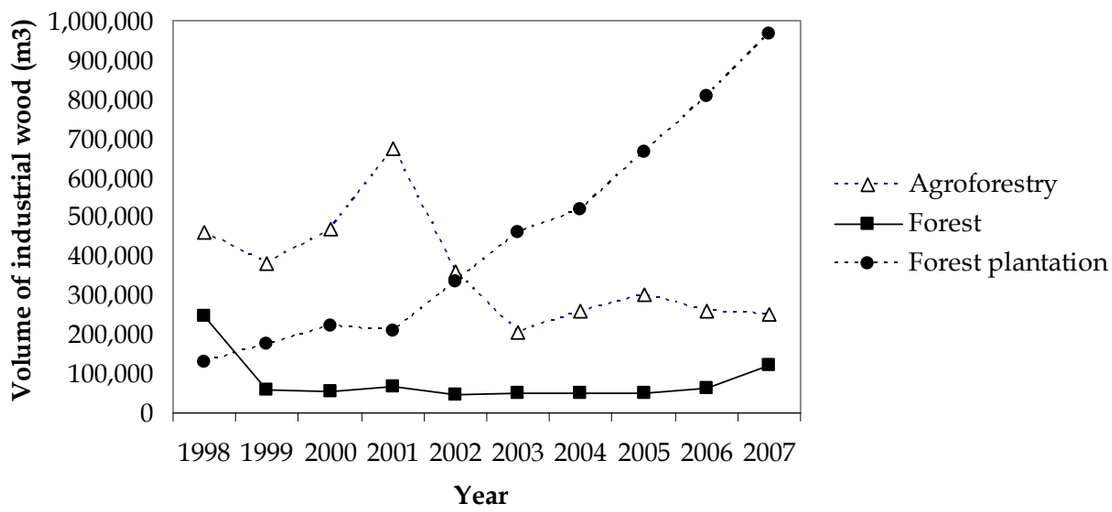

Fig. 1. Amount of industrial wood extracted from agroforestry, forests, and forest plantations during a 10-year period. Source: Oficina Nacional Forestal (ONF) (2009).

Province	*No. contracts*	*Total area (ha)*	*Hectares covered by PES category (No. contracts)*[a]				
			Forest protection	*Reforestation*	*PWA*	*FM*	**Total**
Alajuela	1045	73,516.67	38,292.08 (447)	21,255.07 (443)	6786.8 (63)	2351.82 (31)	**68,685.77 (984)**
Limón	652	70,894.68	52,346.37 (389)	3099.17 (149)	9645.7 (44)	587.32 (10)	**65,678.56 (592)**
Puntarenas	670	69,662.64	56,742.44 (422)	3705.7 (146)	5928 (62)	0	**66,376 (630)**
Guanacaste	1027	63,290.57	46,582.38 (541)	11,130.89 (375)	547.5 (10)	0	**58,260.77 (926)**
Heredia	484	35,722.00	18,989.42 (213)	3885.51 (113)	8745.9 (83)	1792.66 (30)	**33,413.49 (439)**
San José	590	31,165.95	24,462.32 (392)	2430.23 (122)	1785.6 (18)	0	**28,678.15 (532)**
Cartago	130	28,822.38	24,074.58 (90)	848.4 (21)	3429.1 (14)	0	**28,352.08 (124)**
Total	**4599**	**373,074.90**	**261,489.59(2494)**	**46,354.98 (1369)**	**36,868.60 (294)**	**4731.8 (71)**	**349,444.96**

[a]*PWA*= Protection of wildlife area, *FM*= forest management.

Table 2. Current area covered by PES category in the 7 provinces of Costa Rica. Data come from the National Forestry Financing Fund of Costa Rica, FONAFIFO, (2011). Data are ordered according to the total area protected.

The aforementioned trends in forest cover recovery might be related to the different environmental restrictions and government incentives related to the PES established in the Forestry Law 7575. However, other authors suggest that the increase in the forest cover observed in different areas of Costa Rica are in fact a result of a process of "forest transition" (Calvo-Alvarado *et al.*, 2009; Schelhas & Sánchez-Azofeifa, 2006). For instance, Calvo-Alvarado *et al.* (2009) analyzed the process of deforestation and restoration of the tropical dry forest in Guanacaste, Costa Rica, using socioeconomic data and satellite images of the forest cover from 1960 to 2005. They concluded that the restoration of the Guanacaste's forest cover after the 1980s was the result of multiple socioeconomic factors rather than the efficiency of the PES. Similarly, Almeyda *et al.* (2010) found that the proportion of forest cover in the Nicoya peninsula decrease from 0.51 in 1987 to 0.36 in 2008, indicating a poor efficiency of the PES or any other potential deforestation-avoiding strategies implemented by the government during that period.

For this reason, Calvo-Alvarado *et al.* (2009) mentions that neither the PES nor the other conservation policies implemented in the country are enough to protect this tropical dry forest at the long-term. This statement might be particularly true if we take in consideration the multiple financial limitations of the MINAET and the limited number of environmental inspectors of the Secretaría Técnica Nacional Ambiental, the public institution responsible for authorizing the construction and monitoring the environmental performance of the diverse public and private infrastructures along the country (MINAET, *pers. comm.*).

3.3 Relative efficiency of private nature reserves

During the decades 1990s and 2000s the forest area on control of private landholdings was noticeable greater than the forest area on control of the government (Figure 2). Nevertheless, the latter forest area was duplicated from 1990 to 2005 (Figure 2). However, until today, most of the Costa Rican forests (55%) are on control of private landholdings (Food and Agriculture Organization of the United Nations [FAO], 2010b). Overall, the forest cover protected by the private reserves increased *ca.* 2.5 times from 1995 (32,895 ha) to 2010 (81,429 ha) (Programa Estado de la Nación, 2011). Interestingly, from the 200 private reserves recorded until 2010 only a minimal part is managed by individual landowners. Thus, 52% of private reserves are managed by non-government organizations (mainly public universities and non-profit conservationist institutions), 46% are managed by profit organizations, and only 2% are managed by individual landowners (Programa Estado de la Nación, 2011). This fact undoubtedly can benefit the long-term conservation of these areas because contrasting with individual landowners, the activities of the non-profit organizations and universities are frequently monitored by different government institutions and hence, it is more difficult to they change the land use of the forested areas. The deforestation and/or selective logging in reserves management by individual landowners is hard to detect and penalize (particularly when there is not a formal denounce) (Tribunal Ambiental Administrativo, 2011).

On the other hand, considering both private reserves and mixed public-private areas, they cover over 13% of the total continental area of the country while the government-protected forests cover 21% of this area (Table 3). Additionally, as in most America Latina, the main uses of these reserves are ecotourism and investigation (Mesquita, 1999). Furthermore, since private reserves often are located in ecoregions poorly represented in the government system and in regions of the country without existing reserves, they might also contributes to protects a number of threatened animals such as agouti, peccary, jaguar, and puma

(Herzog & Vaughan, 1998). These facts strongly suggest that the private reserves play an important role in the protection of the forest cover in Costa Rica. Even, some of these reserves are also important research centers and frequently receive researches and students of diverse countries of the world. For instance, the La Selva Biological Station protects 1600 ha of primary tropical rainforest, (including 1000 tree species and 420 bird species), and also is one of the most well-studied and recognized tropical rainforest around the world with hundreds of scientific publications in high-impact international journals.

Management category	N	Area (ha)	%STA[a]	% of the country[b]
Goverment-protected areas				
National Parks	28	629,121	37.1	12.3
Biological Reserve	8	22,036	1.3	0.4
Wildlife Refugie	12	61,708	3.6	1.2
Absoult Natural Reserve	2	1,369	0.8	0
Indigenous Reserves	24	335,851	19.8	6.6
National Monument and other reserves	3	23,768	1.4	0.5
subtotal	**77**	**1,073.853**	**64**	**21**
Mixed (Public-Private)				
Wildlife Refugie	25	106,572	6.3	2.1
Protected Zone	31	157,715	9.3	3.1
Forest Reserve	9	221,239	13.0	4.3
Wetland	13	68,543	4.0	1.3
subtotal	**78**	**554,069**	**32.66**	**10.8**
Private Reserves				
Wildlife Refuges	34	68,447	4.03	1.3
Natural Reserves	72	52,156	NA	1
subtotal	**106**	**120,603**	**4.03**	**2.3**

aPercent of total protected area.
bPercent of the continental area of the country (i.e., 51,100 km2).

Table 3. Area covered by public and private protected areas in Costa Rica during 2007. Modified from Food and Agriculture Organization of the United Nations FAO (2010b).

3.4 Relative efficiency of environmental education

The findings indicated that most environment education programs (EEP) in Costa Rica are linked to different ecotourism activities (79% of 29 analyzed studies), following by activities promoted by government and/or non-profit organizations. Currently, most Costa Rican eco-lodges, private reserves, and ecoturism companies have EEPs for employees, visitants and/or local inhabitants (Instituto Costarricense de Turismo [ICT], *pers. comm*.). Even, the EEP is an essential requirement for all those companies and institutions procuring the Certification for Sustainable Tourism (CST, see below). Currently, 178 eco-lodges, 59 tourism agencies, and 4 car rental agencies are certificated (Instituto Costarricense de Turismo [ICT], 2011b), and hence with some type of EEP in course.

Unfortunately, in most cases it is not possible to evaluate the relative efficiency of environmental education as deforestation-avoiding strategy due that its effect is difficult to separate from other complementary conservation strategies. Nevertheless, evidence

suggests that it contributes significantly to reinforce conservation attitudes of the people respect to the deforestation and other environmental problems (Blum, 2008; Koens *et al.*, 2009; Palmer, 1998). Further studies in particular communities of Costa Rica are necessary to evaluate if the environmental education per se is able to minimize, or even revert, the deforestation at the long-term.

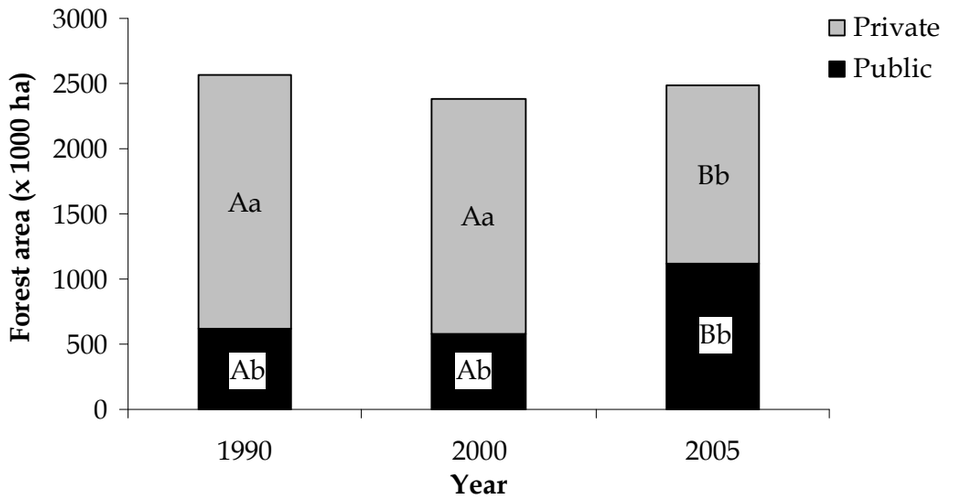

Fig. 2. Changes in the number of forest hectares under government and private management in Costa Rica. Different capital letters indicate significant differences among years, and different lowercase letters indicate differences among reserve type (contrast tests, $P<0.05$).

4. Conclusion and recommendations

Although some limitations (e.g., scarce information on changes in forest cover, lack of quantitative analyses), the information provided in this chapter indicates that, in general, the four strategies analyzed have contributed to discourage the deforestation along the country and contributes to reinforce conservation attitudes in the people.

Thanks to these strategies, the conceptualization of the nature as an obstacle to development has experienced a noticeable change, at least when comparing with the beliefs of some decades ago (see Introduction). However, further studies are critical to improve our understanding on how ecotourism, PES, private reserves, and environmental education contribute to avoid the deforestation and the long-term conservation of the ecosystems. In this sense, field studies analyzing changes in forest cover and/or deforestation rates begin and after the implementation of a determined strategy (using satellite imagery, remote sensing imagery, or other similar methodology) can be particularly useful. Nevertheless, there are indications that one or few isolated conservation strategies are insufficient to deter further deforestation in Costa Rica. Probably the most efficient deforestation-avoiding strategy is not an isolated one, but an integrated conservation program that considers simultaneously the main environmental, social, politic, and economic aspects involving in the phenomenon of deforestation as suggested by Calvo-Alvarado *et al.* (2009). This strategy must take in consideration the appropated planning of multple land uses within the heterogenous landscapes predominant along the country. Government, non-profit organizations, and civil society in general, should priorizing the protection of the more

vulnerable forested areas (i.e., those that contain threated species of animals and plants and/or water reservoir). When necessary, the government should consider the expropriation of some of these areas to guarantee their ecological integrity.

Furthermore, to a more efficient control of the deforestation and/or logging along the country, it is important increase the resources invested in the environmental monitoring. In this sense, are necessary more private and public initiatives to monitoring and penalize the deforestation and other environmental crimes and/or reinforce those initiatives that have showed be successful. For instance, one successful initiative is the 2008' public program namely "barridas ambientales" from the Tribunal Ambiental Admistrativo. In this initiative, a multidisciplinary team of biologists, forest engineers, chemistries, and lawyers carried out sudden visits (5-10 times/year) to different areas of the country and, with the cooperation of the local inhabitants, they detect, record, and sanction any environmental crime (including illegal logging). As result, the number of denounces has been increased by a 100% (Tribunal Ambiental Administrativo, 2011). Other interesting initiative is the program Certification for Sustainable Tourism (CST), from the Instituto Costarricense de Turismo. This program was designed to differentiated businesses of the tourism sector, based on way that they interact with the nature, local communities, and social resources in general (Instituto Costarricense de Turismo [ICT], 2011b).

5. Acknowledgements

I thank Júlio César Bicca-Marques for logistical support for the redaction of this chapter in Brazil. The Ministerio del Ambiente, Energía y Telecomunicaciones de Costa Rica (MINAET) provided important information on changes in the forest cover in different regions of Costa Rica.

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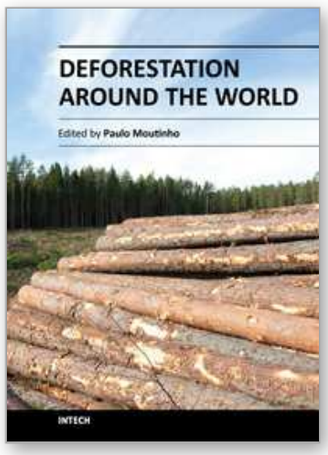

Deforestation Around the World

Edited by Dr. Paulo Moutinho

ISBN 978-953-51-0417-9
Hard cover, 372 pages
Publisher InTech
Published online 30, March, 2012
Published in print edition March, 2012

Deforestation and forest degradation represent a significant fraction of the annual worldwide human-induced emission of greenhouse gases to the atmosphere, the main source of biodiversity losses and the destruction of millions of people's homes. Despite local/regional causes, its consequences are global. This book provides a general view about deforestation dynamics around the world, incorporating analyses of its causes, impacts and actions to prevent it. Its 17 Chapters, organized in three sections, refer to deforestation impacts on climate, soil, biodiversity and human population, but also describe several initiatives to prevent it. A special emphasis is given to different remote-sensing and mapping techniques that could be used as a source for decision-makers and society to promote forest conservation and control deforestation.

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